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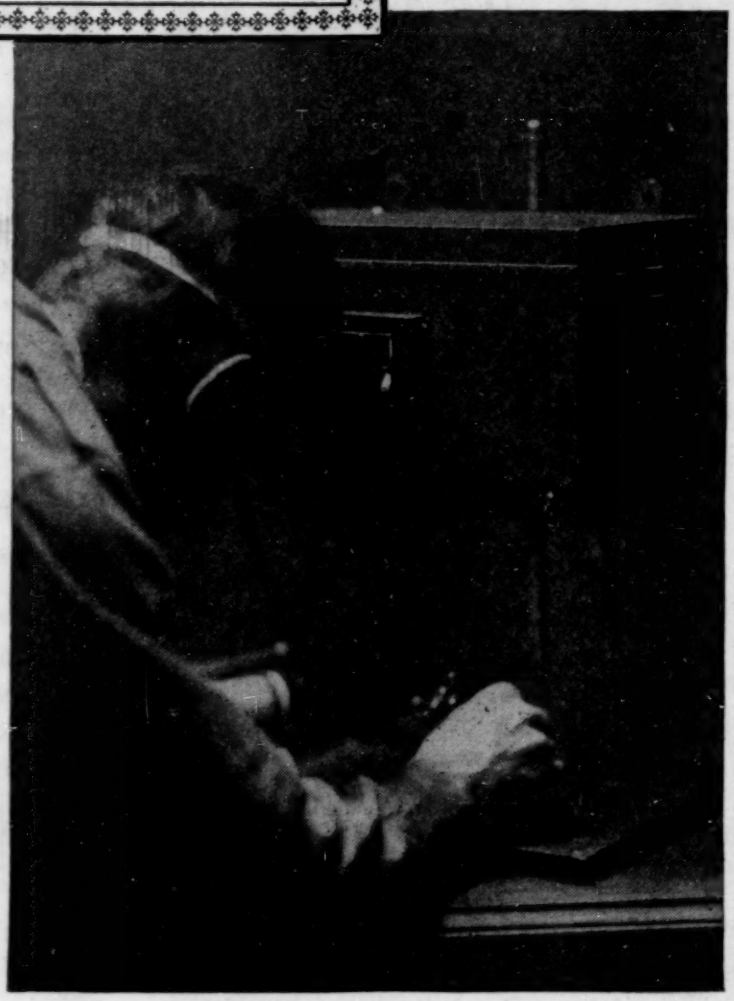

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VOL. LXVI SEPTEMBER 30, 1927 No. 1709

CONTENTS

Reflections of a Chemist: DR. GEORGE D. ROSENGARTEN 287

Does the Net Energy Value of Food depend upon the Purpose for which it is used in the Body? DR. H. H. MITCHELL 298

Ralph Gordon Lusk: PROFESSOR KIRTLEY F. MATHER 292

Professor Albrecht Kossel: PROFESSOR ALBERT P. MATHEWS 293

Scientific Events:
The Imperial Agricultural Research Conference; The Biochemical Institute for the Middlesex Hospital; The Journal of Paleontology; The Rawson-MacMillan Arctic Expedition of the Field Museum; Research in Mining and Metallurgy 293

Scientific Notes and News 297

University and Educational Notes 299

Discussion and Correspondence:
Arsine from Fused Glass: DR. H. M. ELSEY. *Indications of the Transmission of an Acquired Character in Flax:* PROFESSOR HENRY L. BOLLEY. *Mechanism of Buffer Action in Soils:* PHILIP B. MYERS and GERALD M. GILLIGAN 300

Scientific Apparatus and Laboratory Methods:
A Method for obtaining Infective Nematode Larvae from Cultures: G. F. WHITE 302

Special Articles:
Transmission of Potato Witches' Broom to Tomatoes and Potatoes: DR. P. A. YOUNG. *Studies on the Golgi Apparatus of the Mammary Gland:* H. W. BEAMS 304

Science News x

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REFLECTIONS OF A CHEMIST[1]

ANTHROPOLOGISTS divide the era of human existence into ages according to the material of the implements used during a given period—the Stone Age, the Bronze Age and the Iron Age. Far be it from my thoughts to dispute the correctness of this classification, but it does seem a misrepresentation or a wrong characterization to continue the present, or even the preceding, century in the iron age. With the advent of the twentieth century, at the latest, the count of a new age begins. What shall be the name of this age? Your reply may well be anticipated—chemistry. Not your partiality or mine prompts this reply. It is the verdict of facts, for the advances from the stone to the bronze and from the bronze to the iron age are really the results of the progress of the art of chemistry.

The rôle chemistry is playing in the world affairs is too well known to require elaboration. In its broadest embrace—colloidal, catalytic, biological, therapeutic and what not—chemistry is the moving principle of this world of ours. It is nothing less than life and death! We all know the wonders chemistry has accomplished within the short space of time it has been given a systematic unprejudiced trial. These accomplishments and the potentialities of chemical science have also been well advertised, perhaps a little too much. The chemically untutored will expect too much and too soon, with resulting disappointment and reflection on the science and its followers.

IMPORTANCE OF PURE SCIENCE

A far more important problem and one requiring our immediate and undivided attention is so-called "pure chemistry." I should rather like to call it "science of chemistry" in contradistinction to the practical application of chemistry which would be more correctly designated as the "art of chemistry."

Pure science is the protoplasm of applied science. It is the brick and mortar of our sky-scraping buildings of industry and commerce. Our civilization of which we are so proud, the comforts of life we are enjoying, are wholly built on discoveries emanating from the search for scientific truths, from the pursuit of science for the sake of the science itself. As Secretary Hoover has very tersely put it, "It is in the soil

[1] Presidential address delivered at the seventy-fourth meeting of the American Chemical Society, Detroit, Mich., September 5 to 10, 1927.

of pure science that are found the origins of all of our modern industries and commerce."

The relationship between the "science" of chemistry and its varied and multitudinous applications is quite apparent to the chemist, but one or two of the thousands of examples may be cited here. About one hundred and twenty years ago, Sir Humphry Davy, in his pursuit of scientific knowledge for the sake of knowledge, discovered a method of separating the "refractory" metals potassium and sodium from their combinations. Based on this fundamental discovery, Hall, an American, and Heroult, a Frenchman, prepared the metal aluminum. But for the availability of this metal, aviation would still have been a midsummer night's dream. This metal has also added immensely to family happiness. Aluminum kitchen utensils are easy to wash and keep clean, making less work in the household and consequently stabilizing domestic felicity.

This year is the sesquicentennial of the revelation of a simple and great scientific truth. This revelation, known to few and appreciated by still fewer, is the foundation of a very live branch of the applied science of chemistry. In 1777, a French chemist, immortal Lavoisier, enunciated the principle of exchange of gases in respiration. He demonstrated that oxidation in the body and ordinary combustion are analogous processes. This simple scientific discovery marks the real beginning of the science of metabolism. This offspring science of Lavoisier's investigation is, to be sure, still in its infancy, but it is of incalculable importance. It is the very foundation of our existence. What blessings are in store for future generations when this science will have grown to manhood? Disease may then be an unknown term.

We are living on the scientific researches of a hundred or more years ago. We are plucking the fruit of trees of knowledge planted by our forebears. We have worked hard and fast to get all we can out of the funds of discoveries of past centuries, but we can not much longer go on harvesting without planting. We owe to posterity what past generations have provided for us. Shall we fail in our duty and shall we go back on our indebtedness? Our country is spending large sums of money to make available and to extract all the good from the accumulated stores of science, but we are slow to replenish these stores for future generations with fresh materials.

Nature is loath to reveal her secrets. She yields her treasures of knowledge only to those who have consecrated themselves to their quest. No scientific discovery has ever been made by accident or overnight. Archimedes spent many a sleepless hour before he discovered the simple law of displacement of liquids —specific gravity. The falling of an apple did not drop the laws of gravitation into Newton's head. It took him years of hard and patient labor to investigate and propound this law. Nor did the ring formula of benzene come to Kékulé in a dream.

Scientific discovery is the product of three elements —effort, time and genius. Genius is a gift Heaven rarely bestows upon us. We can not bank on it. But we have learned from the laws of physical chemistry that the lack in one factor can be made up by increasing the other. Owing to the enormous benefits we are deriving from scientific discoveries bequeathed to us in the past, we, especially in this country, are in a position to increase the effort factor in the equation.

THE "PHILOSOPHY" OF CHEMISTRY

The significance of chemistry in life processes and its relation to health and disease are beginning to dawn upon us. The achievements and potentialities of the science in peaceful pursuits are becoming recognized and appreciated. Of its force and potency in war we need not be reminded. In our pursuits of the material advantages of chemistry we are liable to overlook and forget its spiritual side, its cultural and educational qualities. Education and culture, terms so commonly used, are but incompletely understood and still less definable. Although at times the conception of culture is purposely corrupted, education misinterpreted and pseudo-cultures substituted and worshipped, honesty and truth are *a priori* the first and last prerequisites of genuine culture and education. The first, uppermost and last principle in chemistry is veracity and honesty. Said Goethe, "The history of a science is the science itself." The history of chemistry clearly shows that success results when truth, and truth only, is courted and adhered to. Disappointment and failure to themselves, their friends, if any they had, and in the long run to the world at large, have followed those—alchemists and their ilk—who pursued the dishonest method of making gold. The names of some of these have survived in history only as object lessons of ridicule. But immortality to themselves, and untold treasures of genuine gold to the world, have come to those who followed the truthful path of science. The first commandment in the curriculum of the study of chemistry is honesty and truth. Such is the irresistible force of this precept in our science that when a student fails to heed it he is automatically eliminated.

Some classes of business people—though to be sure they are back numbers, and in the minority—maintain that chemists make poor business men, because they are too honest and truthful—an unconscious tribute to the science and the high culture of its propounders and followers.

Besides the material advantages it brings to the

world, chemistry is a truly "philosophical" science, in the sense of philosophy as conceived and defined by the great and pure philosophical minds of Socrates, Plato and Seneca. To them philosophy is to teach men to form their souls; knowledge is to be sought for the good of the mind. Our science preeminently fulfils these requirements. Knowledge and contemplation of chemical phenomena, the very varied manifestations of the science, and the subtle and wonderful forms it assumes can not fail to uplift the soul and broaden and purify the mind.

THE CHEMIST'S EDUCATION

The education and training the industrial chemist should have to make him fit and competent in his career is receiving much attention, both from educators and industrialists. Because of the great share of responsibility that is more and more devolving upon the chemist, the importance of this question is self-evident. But in our zeal to hit the spot we are perhaps shooting a little over the mark. The tendency in our curriculum is to stress the applied and industrial chemical courses. I very much doubt that this path will lead to the desired goal. Let me repeat that the industrial achievements of the chemist have resulted from the inspiration he received from his knowledge of the science. Our great and well-known chemical engineers of to-day have been raised on the undiluted milk of the pure science.

Just as in the nutrition of the body a properly balanced food diet must be maintained to insure health and normal development, so it is with the education of the chemist. He must be given a carefully balanced training in the science of chemistry and its application. And I am of the opinion there is decidedly less danger when the ration is increased in the science than the reverse. The greatest names known to science, and to scientific professions, have not during their college careers specialized in the fields they made famous. Overspecialization in youth narrows the mind and stunts its development. Give the chemist student the tissue-building material, the fundamentals of science, impart to him its spirit; then when he goes out to accomplish his life work he will shape and mold the materials according to the need of time and place and will breathe life into them. As in the words of Lowell:

> New occasions teach new duties;
> Time makes ancient good uncouth;
> They must upward still and onward,
> Who would keep abreast of truth.

GEORGE D. ROSENGARTEN

DOES THE NET ENERGY VALUE OF FOOD DEPEND UPON THE PURPOSE FOR WHICH IT IS USED IN THE BODY?

THROUGHOUT his work on the net energy values of feeds for cattle, Armsby[1] has continually kept in mind the probability that the net energy value of a feed varies with the nature of its disposition in the body, for example, varying when used for fattening or for milk production. This probability of a variable utilization of food energy was based in his mind upon the difference in composition of the products formed, indicating differences in the metabolic reactions concerned in the use of food in the basal metabolism and in its conversion into tissue, fat, milk, etc. In the case of milk production, for instance, certain conversions of nutrients are considered as occurring with no loss of energy as heat, while the conversion of carbohydrates to fat is supposed to involve a definite heat liberation. This conception appears to be equivalent to the assumption that the heating effect of food on the animal is determined to a considerable extent by the chemical reactions to which it is subjected after absorption, since the use to which the food is put could obviously have no effect upon the reactions occurring within the alimentary canal.

This conception of Armsby seems to be quite generally held among those laboratories in this country and Europe that are doing calorimetric work upon farm animals, and a number of experiments recently appearing in the literature[2] have been specifically concerned with the relative utilization of the energy of farm feeds in maintenance, fattening and milk production.

It becomes a matter of importance, therefore, to consider what experimental evidence may be cited in favor of the belief that the stimulating effect of ingested food upon animal metabolism is due to the nature of the metabolic reactions to which it is subjected and whether some other conception may not be more readily defended. The theory appears to assume that certain metabolic reactions liberate energy which can be used in maintaining cellular life and activity before being dissipated as heat, while

[1] Armsby, H. P., "The Nutrition of Farm Animals," New York, 1917, pp. 361, 395, 497–8, 563.

[2] Hanson, N., Kungl. Landtbruksakademiens Handlingar och Tidskrift, 1923; Fries, J. A., Braman, W. W., and Cochrane, D. C., U. S. Dept. Agr. Bul. 1281, 1924; Forbes, E. B., Fries, J. A., Braman, W. W., and Kriss, M., *J. Agr. Res.*, 1926, xxxiii, 483; Møllgaard, H., "New Views regarding the Scientific Feeding of Dairy Cattle," Copenhagen.

other metabolic reactions liberate sensible heat only. The latter type of reactions only would be involved in the specific dynamic effect of food. This conception is essentially identical with that put forward by Rubner[3] twenty-five years ago. However, Rubner's theory resulted more as a revulsion against the older theory of Zuntz that the heating effect of food was due solely to the work of digestion, absorption and excretion, than as a probable interpretation of certain specific experimental data. The logic that Rubner used in defending the theory is not convincing at the present time.

In more recent times, Lusk has accumulated much evidence inconsistent with Rubner's theory. In the case of the specific dynamic action of amino acids, Lusk[4] has shown that the reactions of deamination and urea formation are not involved, since two amino acids, glutamic acid and aspartic acid, exert no specific dynamic action in the body, although evidence of their deamination was obtained. Furthermore, although glycine and alanine exert powerful dynamic effects, the products of their deamination, glycollic and lactic acids, exert only inconsiderable effects upon heat production.[5] Lusk has also found that, under certain conditions, the specific dynamic effect of glycine may be as great as the total gross energy content of the amino acid, a result quite unexplainable on the basis of Rubner's theory.

With regard to the specific dynamic effect of glucose, it has been shown by Anderson and Lusk[6] that the ingestion of 70 gms of glucose by a working dog is without effect upon its heat production, although in the same dog at rest a very marked effect is produced. In both cases, oxidation of glucose occurred, and hence, according to Rubner's theory, the specific dynamic effect should be the same. Baumann and Hunt[7] observed a definite effect of the ingestion of 25 gms of glucose in the normal rabbit, but no effect in the thyroidectomized rabbit, although with both groups of animals oxidation of glucose was occurring as indicated by the respiratory quotient.

The fact that the ingestion of small amounts of foods may produce no effect on heat production is significant in this connection. According to Rubner's theory, the specific dynamic effect of a food material should be proportional to the amount ingested when it is being used for the same purpose. However, Lusk has found that his experimental dogs showed no response to the ingestion of 10 or 20 gms of glucose, although with 50 to 70 gms marked increases in heat production were observed. Similarly, it has been shown that the ingestion of a small breakfast by human subjects does not appreciably affect a subsequent basal metabolism determination.[8]

Among human subjects there are certain pathological conditions, such as certain types of obesity, certain diseases resulting from endocrine deficiencies and certain neuroses, in which the specific dynamic effect of food is either non-existent or distinctly subnormal.[9] To explain this situation on the basis of Rubner's theory would necessitate the assumption that in these disorders the metabolic reactions are markedly abnormal and are all of the type in which liberated energy can be completely utilized in covering the energy requirements of the tissues. The improbability of this assumption requires no elaboration.

Finally, if the specific dynamic action of food were due to the metabolic reactions to which it is subjected, one would expect that it could be calculated from the composition of the food, its digestibility and the average heating effects of the different nutrients of which it is composed. However, Armsby[10] has shown quite conclusively that this can not be done by any rational method in the case of cattle. Similarly, in the case of dogs, the heating effect of a protein can not be predicted from its amino acid constitution.[11]

From these considerations, it appears that Rubner's theory of the specific dynamic effect of food is not in agreement with many of the observed facts of energy metabolism, and hence is no longer tenable. It is interesting to inquire, therefore, if any other theory would lead to the conclusion that the heating effect of food on metabolism will vary depending upon the manner of its utilization.

The theory that Lusk sponsors on the basis of his own extensive investigations is that the specific dynamic effect of food is due to a stimulating effect on cellular oxidations, brought about either by the mere presence of an excess of oxidizable matter in the intercellular fluids (in the case of sugar and fat) or by a stimulus of some other type not so clearly definable (in the case of amino acids). The theory

[3] Rubner, M., "Die Gesetze des Energieverbrauchs bei der Erhähnrung," Leipzig and Vienna, 1902, pp. 356–407.

[4] Lusk, G., *J. Biol. Chem.*, 1915, xx, 555; Atkinson, H. V., and Lusk, G., *Ibid.*, 1918, xxxvi, 415.

[5] Lusk, G., *J. Biol. Chem.*, 1921, xlix, 453.

[6] Anderson, R. J., and Lusk, G., *J. Biol. Chem.*, 1917, xxxii, 421.

[7] Baumann, E. J., and Hunt, L., *J. Biol. Chem.*, 1925, lxiv, 709.

[8] Benedict, C. G., and Benedict, F. G., *Boston Med. and Surg. J.*, 1923, clxxviii, 849.

[9] Plaut, R., *Deutsch. Arch. klin. Med.*, 1922, cxxxix, 285; 1923, cxlii, 266. Liebesny, P., *Biochem. Z.*, 1924, cxliv, 308. Wang, C. C., and Strouse, S., *Arch. Intern. Med.*, 1924, xxxiv, 573.

[10] *Loc. cit.*, pp. 667–673.

[11] Rapport, D., *J. Biol. Chem.*, 1924, lx, 497.

does not lead one to suppose that the ultimate destination of the food in metabolism is a factor in determining its specific dynamic effect, since this effect depends primarily on the concentration of nutrient material within and around the cells. For a given intake of food, any factor that would tend to vary this concentration during absorption would have a corresponding effect upon heat production. This nutrient concentration in the tissues would be depressed by any factor increasing the rate of disposal of the excess food material, such as muscular activity or mammary activity. Hence, on the basis of Lusk's theory, one would expect a smaller heating effect of a given amount of food in a lactating cow than in a dry cow, though no constant difference would be expected for different amounts of milk produced and different amounts of food consumed. If the cow is a high producer, it is evident that in the first few months of lactation, when the animal is in a condition of "physiological underfeeding," the food consumed would presumably exert only a minimal heating effect,[12] and would thus possess a high net energy value. In the later stages of lactation, when the animal may be laying on fat due to overfeeding, the heating effect of the same amount of food may be much greater, if the rate of fat deposition is much less than the rate of milk formation, as it quite probably is. At this time, the net energy value of the food would be less than at first.

On similar reasoning, it would appear that the net energy value of food fed at the maintenance or submaintenance level would be higher than at the higher levels, not because of the different metabolic reactions involved in fattening as compared with maintenance, but because of a probable slower rate of withdrawal of nutrients from the intercellular fluids in the deposition of fat than in the satisfaction of contemporary energy requirements. However, the difference would probably not be a constant one, since the heating effect of a unit of food would presumably vary in each case with the level of feeding. On the same grounds, it would be expected that the net energy value of food would be greater when muscular activity is occurring simultaneous with absorption of food from the intestinal tract, than when the animal is at rest; on the other hand, work performed in the post-absorptive period would be without influence on the utilization of food energy.

[12] Thus, Widmark and Carlens (*Biochem. Z.*, 1925, clvi, 454) observed that the blood sugar content of lactating cows was less than that of dry cows, and that the depression from the normal value was in rough proportion to the amount of milk produced. The lowest values observed were less than half (0.040 per cent.) the average value for dry cows (0.085 per cent.).

It appears, therefore, that Lusk's experimental work affords no grounds for believing that the manner in which food is utilized determines the extent of utilization through its effect on the specific dynamic action of the food. It is true that the net energy value of a food may be expected to be different with animals functioning in a different manner, but it would seem that no characteristic or even approximately constant net energy value can be assigned for a given function, and that no constant relation of net energy values among different functions can be assumed. In particular, it appears unjustifiable to assume that, in an animal utilizing food in a number of different ways, so much metabolizable energy is being used for maintenance, and so much for milk production, since, if mammary activity increases the net energy value of the food by preventing as great a "metabolism of plethora" as would otherwise occur, this increased utilization would apply as much to the food used for maintenance as to that used in the production of milk.[13]

Another possible explanation of the heating effect of food on animal metabolism is that the acid products of digestion may be effective stimuli to cellular activ-

[13] A specific illustration of this point may aid materially in appreciating this argument. In a recent article by Forbes, Fries, Braman and Kriss (2), estimates are made of the utilization of metabolizable energy for milk production, by making certain definite assignments of metabolizable energy for maintenance and body increase, and relating the remainder to the energy content of the milk produced. Thus for Cow 874 (in Tables 5, 6 and 7) it is assumed that the metabolizable energy used for maintenance suffers a loss of 22.3 per cent. as heat, that used for body gain a loss of 38.4 per cent., and hence that used for milk production a loss of 27.8 per cent. The total heat increment for this cow is an experimental observation, but the factoring of it in this manner on the basis of results obtained on the cow when dry is an interpretation that involves theoretical considerations that have neither been justified nor discussed. Hence, the conclusion that the percentage utilization of metabolizable energy for milk production was, for this cow, 72.2 per cent., is an interpretation of the same character. The essential assumption upon which these interpretations are based is that when food is serving a number of purposes in the animal body simultaneously, the utilization of food energy for each purpose is independent of that for the other purposes; in other words, that the heating effect of food used for maintenance is the same whether the animal is producing tissue or milk simultaneously or whether it is only maintaining its *status quo*. While this assumption superficially appears to be a reasonable one, on analysis it is seen to imply that the causes of the heat increment due to the ingestion of food are related directly to the methods of food disposal, *i.e.*, to the metabolic reactions concerned in maintenance, body gain and milk production.

ity. This explanation has been proposed by Benedict,[14] though direct attempts to verify it have not been successful.[15] It is conceivable, however, that acid stimulation may be an important factor with ruminants, in which large amounts of organic acids resulting from extensive bacterial fermentations are absorbed from the intestinal tract. But obviously this theory also can not be construed to favor the view that a definite net energy value for a food is characteristic of each animal function, or that the percentages of utilization of metabolizable energy for different functions bear a constant relation to one another.

Finally, in ruminants at least, the chemical, bacterial, glandular and muscular events occurring in the alimentary canal, or in its accessory organs, during digestion are known to result in a definite and considerable increase in heat production, an increase that may account for a large percentage of the total heat increment following the ingestion of food. But it appears that these events, and the accompanying heat losses, would bear no relation to the events subsequently or simultaneously occurring on the other side of the gastro-intestinal mucosa. They would presumably be related, more or less constantly, to the amount of food consumed, and its physical and chemical make-up, particularly as this bears upon the extent and rapidity of its digestion, but would be quite unrelated to the manner in which the food is utilized after absorption.

It appears, therefore, that the determination of the relative net energy values of feeds for animals in different functional conditions is being approached on the basis of assumptions, not only without experimental justification, but even in contradiction to established experimental findings. The results obtained, in consequence, are being given a significance that they do not seem to possess, in all probability. Hence, a different working hypothesis should be adopted. Since Lusk's experimental work and the theories that he has deduced from it appear to offer the most plausible explanation of the specific dynamic action of food—the only calorigenic effect of food that would conceivably be related to its disposal in metabolism—a working hypothesis based upon these theories would seem to be the safest guide in future investigations of the net energy values of food for farm animals.[16] In a broad way, these theories differentiate three general lines of investigation, involving studies of (1) the heating effect of different amounts of food in animals in the same functional condition, (2) the heating effect of the same amount of food in animals in different functional conditions, and (3) the influence of internal factors, such as heredity and endocrine activity, upon the specific dynamic effect of food. The first study is concerned with the rate of establishment of the metabolism of plethora, the second with the rate of its depression due to withdrawal of food by the tissues and the third with the response of the tissues to a given plethora stimulus; in other words, with the irritability of the tissues.

H. H. MITCHELL

COLLEGE OF AGRICULTURE,
UNIVERSITY OF ILLINOIS

[14] Benedict, F. G., Trans. 15th Intern. Congress Hyg. and Demography, Washington, D. C., 1912.

[15] Lusk, G., *J. Biol. Chem.*, 1921, xlix, 453; Taistra, S. A., *ibid.*, 479; Chanutin, A., *ibid.*, 485.

[16] It may, of course, be objected that Lusk's work was done with carnivora and that the conclusions from it can not be assumed to apply to herbivora. However, there is little reason for believing that the energy metabolism of the two types of animals is fundamentally different. In any case, the theories of Rubner as well as those of Lusk were based upon experimental work with carnivora. Until there is definite reason for doubting the applicability of experimental data so obtained to farm animals, they may be considered a safe guide upon which to base working hypotheses.

RALPH GORDON LUSK

DR. RALPH GORDON LUSK, instructor in geology at Harvard University, died suddenly with heart failure in New York City on July 27, at the age of thirty-one years, just as he was entering upon his career as a geologist. He was born July 14, 1896, at Manchester, Iowa, where his father, the Reverend C. F. Lusk, was at that time pastor of the First Baptist Church. His mother's maiden name was Grace A. Hilbrant. Ralph Lusk was educated in the public schools of Iowa, and in March, 1918, he enlisted in the U. S. Navy and was sent to the Great Lakes Naval Training Station. On April 1 of the same year he was married to Neva Belle Frederick at Lake City, Iowa. At Great Lakes, the heart ailment which finally caused his death was first developed and by September he was discharged for vocational rehabilitation. He entered Denison University that fall and graduated with the class of 1922, after making geology his major subject. The next year was spent as a graduate student at the University of Chicago. At Denison he was elected to membership in Phi Beta Kappa and at Chicago to Sigma Xi. In 1923–24 he was instructor in geology at Denison and in 1924 he entered Harvard University as an Austin Teaching Fellow in Geology. He was appointed instructor in geology in 1926 and in June, 1927, he was awarded the degree of doctor of philosophy at Harvard, having previously received the degree of master of science from Chicago.

During the summer of 1922, Ralph Lusk had served as field assistant to Kirtley F. Mather, of the U. S. Geological Survey, in Colorado and New Mexico. Shortly thereafter he was appointed assistant geologist on the survey and spent the summer of 1923 in Montana as assistant to A. J. Collier. Similarly during the field season of 1924 he was engaged in geological mapping in northeast Colorado for the United States Geological Survey, and during the field season of 1925 and 1926 he was in eastern Tennessee as geologist of the State Survey. This field work supplied the basis for his doctor's thesis as well as shorter technical articles. He was also one of the joint authors of a government bulletin, now in press, descriptive of the oil and gas resources of northeast Colorado.

Dr. Lusk was a member of Beta Theta Pi and a Mason. He is survived by his widow and four children: twin daughters, aged eight; a son, Ralph Gordon Lusk, Jr., aged four, and a baby daughter, nine months old.

KIRTLEY F. MATHER
HARVARD UNIVERSITY

PROFESSOR ALBRECHT KOSSEL

GEHEIMRATH PROFESSOR ALBRECHT KOSSEL, until recently professor of physiology in Heidelberg University, director of the Heidelberg Institute for the Study of Proteins, Nobel prize winner, known for his elucidation of the chemistry of the proteins and of nuclear chromatin matter, died unexpectedly, after a very short illness, in Heidelberg on July 5.

Professor Kossel in a very real sense was the founder of modern biochemistry. It was his conception of the structure of the proteins, following upon his study of the simplest of these substances, the protamines, a conception which was confirmed and established by synthesis of artificial or synthetic proteins by Emil Fischer, work undertaken at Professor Kossel's suggestion and request, which gave to biochemistry its great impetus in the last years of the nineteenth century and led to the wonderful outburst of activity in this field.

Professor Kossel was a fine-looking man of medium height, of a simple, friendly, affectionate and generous nature. He had nothing of the insolence, conceit and arrogance so often associated with the Prussian, but he was a real scientific man, modest, kindly, simple, sincere, with a brilliant imagination and indefatigably at work in the laboratory even up to the time of his death. He retained his youthfulness of appearance, of mind and outlook and all of his faculties to the very end of his life. To his great honor it may be recalled that he did not sign the ridiculous pronunciamento of the German professors at the start of the great war. He did not sympathize with those who brought on the war, although after his country was engaged he gave it loyal support.

Ever since the death of Hoppe-Seyler he had been editor of the *Zeitschrift für Physiologische Chemie,* being associated for a year or two and until the death of the latter with Professor Baumann, but being thereafter sole managing editor. This journal, established by Hoppe-Seyler about 1879, was for many years the only journal in the world devoted exclusively to biochemistry and it is one of the finest journals of science of the present day, its papers being almost without exception valuable contributions to the subject and several of them being classics in their fields.

Mrs. Kossel, whom many American students and friends will remember with great affection for her kindness, sincerity and intelligence, and who was related to some of our most distinguished scientific men, died in 1912. Two children survive them; a son, the distinguished physicist of Kiel, Professor Walther Kossel, and a daughter, Gertrud Kossel; and three grandchildren, Albrecht, Dierick and Irene Kossel. Professor Kossel was a brother of the bacteriologist, Professor H. Kossel, who died about two years ago.

Professor Kossel had many pupils, his laboratory in Heidelberg being filled before the war with students from all lands. His death is felt by them all as a great personal loss. It removes another of the great men of science of Germany, the greatest glory of that country in the years just preceding the war. As one after another of these great men pass away it is as if one light after another were being extinguished and Germany entering again into the twilight of learning.

ALBERT P. MATHEWS

SCIENTIFIC EVENTS

THE IMPERIAL AGRICULTURAL RESEARCH CONFERENCE

THE Imperial Agricultural Research Conference which opens in London on October 4 has, according to a report in the London *Times,* as its main objects the establishment of closer cooperation in agricultural research work throughout the empire, the setting up of additional research stations in tropical and subtropical countries, the creation of greater imperial bureaus, and the recruitment, training and interchange of research workers. It will be attended by seventy-five delegates of high administrative and scientific standing from the oversea parts of the empire and by many representatives from Great Britain and

Northern Ireland. The Dominions and India are sending thirty delegates, and representatives of the Colonies and Protectorates will attend from Barbados, British Guiana, Ceylon, Cyprus, Gold Coast, Kenya, Leeward Islands, Malaya, Mauritius, Nigeria, Nyasaland, Palestine, Sierra Leone, Tanganyika, Trinidad, Grenada and Windward Isles, Uganda, Zanzibar and Sudan.

Lord Bledisloe, the parliamentary secretary to the Ministry of Agriculture, is the chairman of the organizing committee, and the members of the conference, in addition to various representatives of the Ministry of Agriculture, the Colonial Office and the Board of Education, include the High Commissioners for the Dominions, representatives of the Empire Marketing Board, the Department of Scientific and Industrial Research, the Medical Research Council, the Bureaus of Entomology and Mycology, the Overseas Settlement Department, the University Grants Committee, the Department of Overseas Trade and the Forestry Commission.

The importance and value of such a conference was first urged by the Agricultural Research Council several years ago, and since then the matter has been discussed by the Imperial Conference and the Colonial Office Conference. Recently Lord Lovat's Committee on Agricultural and Research Administration in the non-self-governing Colonies put forward recommendations for closer cooperation on these matters. The conference will be held in the Grand Committee Room of the Houses of Parliament, and will be opened on October 4 by the Minister of Agriculture. In the evening the delegates will be the guests of the government at a dinner in the Royal Gallery, House of Lords. Till October 7 the full conference will discuss the agenda of administrative questions, and the organizing committee anticipate that this will lead to the appointment of commissions to examine in detail and prepare reports and recommendations on the question of the extension of the system of imperial bureaus from entomology and mycology to other departments of agricultural science. It is probable that recommendations will be put forward for the setting up of empire bureaus in veterinary science and for investigating soil problems and plant breeding, and also for a bureau on agricultural economics. The desire of the Australian Government to set up a research institute at Queensland on subtropical agriculture will also come before the conference. Specialist commissions are to be set up to bring together the delegates interested in a special subject of research and to assist in the formulation of schemes of combined research work. The full sessions of the conference will be resumed on October 24 and continue for four days. During the intervening period part of a program of visits to research centers will be carried out.

The University of London will hold a reception at the Imperial Institute, and the delegates during their stay in London will have the opportunity of viewing at the Science Museum a special exhibition illustrating the history of agricultural implements and of inspecting at the British Museum manuscripts and books dealing with agricultural science. Arrangements are being made at both museums for lectures on such subjects and special pamphlets will also be provided for the use of the delegates. On October 14 the Vice-chancellor of Cambridge University will give a luncheon to the delegates, and after inspecting the various departments of scientific research the party will leave for Edinburgh on October 18. The headquarters of the conference will remain in Edinburgh until October 22. Afterwards delegates will have the opportunity of visiting Aberdeen to inspect the work of the Rowett Institute in relation to animal nutrition and visiting Belfast, where they will be entertained by the Government of Northern Ireland and shown the plant breeding, poultry and animal diseases research stations.

The reports of the various commissions appointed will be considered by the full conference in London between October 24 and 27. On October 29, the party will visit the Rothamsted Experimental Station, on October 31 the Royal Botanic Gardens at Kew, on November 1 the East Malling Research Station, and on November 2 Oxford University, including the Institutes of Agricultural Economics Research, Agricultural Engineering and Imperial Forestry.

THE BIOCHEMICAL INSTITUTE FOR THE MIDDLESEX HOSPITAL, LONDON

THE Middlesex Hospital, already distinguished by the Bland-Sutton Pathological Institute, has now, according to the *Journal* of the American Medical Association, the further distinction of an institute of biochemistry, thanks to the gift of $200,000 by Mr. S. A. Courtauld. At the opening ceremony, Mr. A. E. Webb-Johnson, honorary treasurer of the medical school, recalled that it was only a few years since Mr. Courtauld gave $100,000 to endow the chair of anatomy, "one of the fundamental medical sciences." The foundations of scientific work in the Middlesex Hospital Medical School were laid by Sir John Bland-Sutton before the war, by his gift of the pathologic institute bearing his name. "Dictionaries printed before the year 1900 contain no such word as biochemistry, but the name is now familiar, and though new the science is old," said Sir John Bland-Sutton, in an address on "Biochemistry in Relation to Medicine," a science concerned with the application of the princi-

ples of chemistry and physiology to the investigation and interpretation of the phenomena of life. He referred to the fact that the kingdoms of nature had been arranged in three classes: mineral, plants and animals. The microscope revealed myriads of minute living things concerning which biologists were puzzled to decide whether they were plants or animals. Such discoveries bridged the gap between the two, and it was now the ambition of biochemists to discover the connecting link between stones and plants, in order to find out how life arose from inorganic matter. He had always maintained that laboratories for investigating disease should be in close association with hospitals. The future of medicine does not lie in prescribing drugs, he declared. The day may come when, some of us believe, the biochemical laboratory may displace the dispensary. Lavoisier, the founder of biochemistry, had his head lopped off in 1794, continued Sir John, by the "apostles of Liberty, Equality and Fraternity," on the excuse that the republic had no need for scientists. Mr. Courtauld had no fear that such a fate awaited him. The wisdom shown in building the laboratory indicated his appreciation of the great part science played in practical medicine. "We may be hopeful," he concluded, "that a discovery will one day be made within the walls of this laboratory which will make the world gape with astonishment." The institute will be a five-floor building, the four upper ones having laboratories for the study of the various branches of biochemistry, all equipped with the latest appliances.

THE JOURNAL OF PALEONTOLOGY

NUMBERS one and two of a new quarterly known as the *Journal of Paleontology* appeared in July and August, respectively. Numbers three and four are expected to appear in October and December. In future years the numbers will appear at three-month intervals.

The *Journal of Paleontology* is the official publication of the Society of Economic Paleontologists and Mineralogists.

The Society of Economic Paleontologists and Mineralogists is an organization whose object, as stated in Article II of its constitution, is "to promote the science of stratigraphy through research in paleontology and sedimentary petrography, especially as they relate to petroleum geology," and whose membership is composed of members or associate members of the American Association of Petroleum Geologists engaged in such work.

The Journal of Paleontology will be devoted to research in paleontology and sedimentary petrography. The paleontological papers will include those pertaining to faunal distribution, stratigraphic index species, descriptions of individual faunas, relation of zones to habitats, etc. Sedimentary petrographical papers will pertain to mineral zones, stratigraphic distribution, provinces of sedimentation, etc. Papers will also be included which pertain to technique bearing on researches in paleontology and sedimentary petrography. In fact, those papers will be included which will in any manner be helpful to those engaged in stratigraphic studies carried on either in the laboratory or in the field.

The Journal of Paleontology is a quarterly publication, and will be of approximately 96 pages and 15–20 plates. It is 6¾ x 9½ inches in size.

Dr. Joseph A. Cushman is editor. He is one of America's most active micro-paleontologists. He has been engaged in research for many years, and is now one of the world's foremost authorities on the foraminifera. He will have associated with him an editorial board to assist in matters not in his particular field.

MARCUS A. HANNA,
Secretary-Treasurer.
SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS,
HOUSTON, TEXAS

THE RAWSON-MACMILLAN ARCTIC EXPEDITION OF FIELD MUSEUM

WILLIAM DUNCAN STRONG, anthropologist of the expedition and a member of the staff at Field Museum of Natural History, in a report made public by the director of the museum, tells how the explorers have come upon the ruins of the house, the mining pits and the improvised shipyard of Sir Martin Frobisher, who, between 1576 and 1578, led three expeditions, two for gold, into the forbidding regions of Labrador and Baffin Land. Digging in the ruins, Dr. Strong has unearthed fragments of brick, plaster, coal and porcelain, products which he states undoubtedly were brought over from England, and are indisputable proof that the ruins are of European, and not native Eskimo, habitations.

The story of Frobisher, recalled by the museum expedition's findings, is one of the most romantic in the history of quests for riches in far parts of the earth. Frobisher, with the financial assistance of a few friends, sailed from England in July, 1576, in search of a northwest passage to Cathay and India. He had two tiny vessels, *The Gabriel* and *The Michael,* and thirty-five men. Arriving in Labrador, they proceeded up the coast to what is now Frobisher Bay in Baffin Land. Five of the men were captured by natives and never seen again. Failing to find the passage they sought, the expedition returned to England, bringing some specimens of what the sailors called

"black earth." Soon a rumor spread that this black earth was gold ore. Frobisher himself is thought to have believed it.

In the excitement that ensued, another expedition was formed. Queen Elizabeth loaned *The Aid,* a larger naval vessel, to Frobisher, and gave him £1,000 to finance the quest. Men of prominence in the court also invested in the hope of recovering large fortunes. In July, 1577, Frobisher, with *The Aid,* and the two vessels he had previously, and 120 men, sailed again. Mining equipment was carried and miners and refiners were included among the men. The following autumn the expedition returned to England with 200 tons of the "ore." While assaying, delayed in various ways, was going on, excitement mounted higher, and a third expedition was organized, with fifteen ships. Plans were made to leave 100 of the men to establish a permanent settlement in the barren land, which had solemnly been taken possession of in the queen's name. The fleet sailed May 31, 1578.

After arrival in Frobisher Bay, dissensions arose, and the idea of the settlement was abandoned. The fifteen ships, all laden to capacity with ore, returned to England in October, only to find that the assay, since completed, had determined that the ore contained nothing but "fool's gold," or iron pyrites.

Dr. Strong reports also having investigated what were believed by some explorers to be Norse ruins in Labrador and Baffin Land, but states all he has seen thus far are Eskimo in origin. Further search is to be made for evidences of a landing by the Vikings in the region.

Skeletons of three Labrador Eskimos from old stone graves, other contents of the graves, various specimens from ancient camp sites and many specimens of Eskimo handiwork in bone and stone implements have been collected for the museum.

Dr. Strong is now making preparations for a trip during the coming winter. While other members of the expedition are working at the scientific station established at Nain, Labrador, he will go, with a native interpreter and a team of dogs, into the interior to mingle with and study the primitive Naskapi Indians. These tribes, of which little is known at present, are one of the most primitive of extant peoples. They are reported to be surly and untrustworthy and disinclined to welcome white intruders.

RESEARCH IN MINING AND METALLURGY

FIFTEEN different research studies in mining and metallurgy are being carried on this year at the Carnegie Institute of Technology in cooperation with the United States Bureau of Mines and two advisory boards of mining engineers, metallurgists, steel operators and chemists, according to an announcement. Thirteen of the problems are being investigated by college graduates appointed as research fellows, one by a research engineer and another by an analyst.

This year's work, it is announced, is a continuation of the program that has been in effect for several years. Each research fellow is making his studies under the direction of a "senior investigator" representing the Bureau of Mines and a member of the faculty of the Carnegie Institute of Technology. Four of the fellowships are financed this year by the institute. Other organizations contributing to the expenses and the fellowship funds are the American Gas Association, the New York Edison Company, the Philadelphia Storage Battery Company, the National Coal Association, the International Combustion Engineering Corporation, and twenty-six companies representing the metallurgical industries. The latter group is financing six of the investigations.

As in former years, it is announced, the results of the studies will be published in bulletin form for distribution at the close of the college year. Assignments of problems to the research fellows have been made as follows:

Equilibrium between manganese, iron and sulphur, by Hershall V. Beasley, University of Tennessee.

Synthesis, testing and application of warning agents for manufactured gas, by Harry A. Brown, Lehigh University.

Formation and identification of inclusions, by John M. Byrns, Case School of Applied Science.

Coal ash fusibility as related to clinker formation, by Clarence L. Corban, Rose Polytechnic Institute.

Methods of determining inclusions, by John F. Eckel, University of Kansas.

Distribution of iron oxide between slag and metal, by Hyman Freeman, Georgia School of Technology.

Base exchange in relation to decay and peat formation, by Raymond C. Johnson, Monmouth College.

Safety, costs and efficiency of distribution of electric power in coal mining, by Donald C. Jones, research engineer.

Physical chemistry of steel making, by Frank Morris, analyst.

Relation between composition and oxidizability of coal, by Harold M. Morris, Cornell College.

Viscosity of open-hearth slag, by Frank G. Norris, Purdue University.

Composition of oils and heavy tar from distillation of coal at low temperature, by Robert N. Pollock, University of Washington.

Determination of relative ignitibility of low temperature coke compared with coal, by Donald L. Reed, University of Washington.

Study of cause and control of abnormality in case carburized steel, by Alfred W. Sikes, University of Illinois.

Physical chemistry of steel-making (field studies), by R. W. Stewart, Massachusetts Institute of Technology.

SCIENTIFIC NOTES AND NEWS

PROFESSOR ALBERT A. MICHELSON, of the University of Chicago, left on September 24 for Pasadena, with the object of repeating at the Mount Wilson Observatory the Michelson-Morley experiment. Dr. Michelson will also make a further study of the speed of light.

IT is reported in the London *Times* that English scientific men attending the International Congress of Physics, held at Como in celebration of the Volta centenary, included Dr. F. W. Aston, of the Cavendish Laboratory of Cambridge; Professor A. S. Eddington, Sir Edward Rutherford and Sir J. J. Thomson, of the University of Cambridge; Professor W. L. Bragg, of the University of Manchester, and Dr. J. A. Fleming and Professor O. W. Richardson, of the University of London.

IN honor of an investigation on the measurement of the efficiency of the output of a dynamo, the results of which were reported to the Franklin Institute of Philadelphia fifty years ago by Dr. Elihu Thomson and E. J. Houston, then of the Central High School, Philadelphia, the institute and the General Electric Company plan to hold a celebration in March. Dr. Thomson and Dr. Charles F. Brush, of Cleveland, Ohio, will be the guests of honor.

DR. HERBERT E. IVES will demonstrate his invention of television in an address before the Franklin Institute of Philadelphia on November 16. He has been awarded a John Scott Medal.

DR. EDWARD R. WEIDLEIN, director of the Mellon Institute of Industrial Research, University of Pittsburgh, and president of the American Institute of Chemical Engineers, has been elected an honorary member of the Chemical, Metallurgical and Mining Society of South Africa.

DR. G. R. MANSFIELD, of the U. S. Geological Survey, has been placed in charge of the combined sections of areal geology and the geology of non-metalliferous deposits. Dr. H. D. Miser is in charge of the section of the geology of fuels.

MRS. CARL AKELEY, widow of the explorer, has been appointed adviser in the development of the new African hall of the American Museum of Natural History.

SIR MURDOCH MACDONALD has been elected president of the British Junior Institution of Engineers in succession to Engineer Vice-Admiral Sir Robert B. Dixon. Sir Murdoch will take office at a meeting to be held on November 18, when he will deliver his presidential address.

AT the meeting of the International Electrotechnical Commission, which opened at Bellagio on September 12, officers were elected as follows: President, C. Feldmann, Delft, Holland; honorary president, Guido Semenza, of Italy, the retiring president; honorary secretary, Kenelm Edgcumbe, of Great Britain, *vice* Sir Richard Glazebrook, resigned. The next meeting will be held in the United States in September, 1928. In 1930 the conference will go to Stockholm.

PROFESSOR M. H. INGRAHAM, of the University of Wisconsin, was appointed assistant secretary of the American Mathematical Society, in charge of arrangements for western meetings of the society, at the recent meeting of the organization in Madison. Professor Ingraham succeeds Professor Arnold Dresden, who for the past eleven years has served as assistant secretary of the society. Professor Dresden leaves the University of Wisconsin this autumn to become head of the department of mathematics at Swarthmore College. The society commended Professor Dresden's work during his term of office in resolutions adopted at the closing business session.

GRANTS made by the Committee on Scientific Research of the American Medical Association include $500 to Dr. Helen Bourquin, professor of physiology in the University of South Dakota, to continue her study of experimental diabetes insipidus; and $500 to Dr. C. W. Apfelbach, Chicago, to study some of the functional alterations of the kidneys of dogs following infarction of glomeruli, and $300 to Dr. Roy H. Turner to enable him to continue his researches into the gastro-intestinal microbiology in pellagra and sprue.

DR. G. B. L. ARNER, agricultural statistician of the division of statistical and historical research of the U. S. Department of Agriculture, tendered his resignation effective on September 1 after five years' service in the bureau. He has accepted a position as the chief of the bureau of vital statistics of the Department of Public Health, for the State of Pennsylvania.

H. ATHERTON LEE, pathologist at the Experiment Station of the Hawaiian Sugar Planters' Association in Honolulu, has resigned to accept the position of director of research for the Philippine Sugar Association in Manila, P. I. He will take up his new duties on November 16.

MILTON E. RYBERG, formerly of the division of agricultural biochemistry of the University of Minnesota, has taken up work at the Boyce Thompson Institute for Plant Research, Inc., at Yonkers, N. Y., and is working on the volatile constituents of plants attacked by the European corn borer.

PROFESSOR EDWARD W. BERRY has returned to Baltimore after spending three months in geological studies in Ecuador and Peru.

DR. A. S. HITCHCOCK, custodian of grasses in the National Herbarium, has returned from a trip to Washington, Oregon and California. In cooperation with the Forest Service he traveled through Cascade, Deschutes and Umpqua Forests of the Cascade Mountains and the Siskiyou Forest of the Coast Range. He also visited Mount Hood and The Dalles.

DR. REID BLAIR, director of the New York Zoological Park, is in London on a mission to study the recent installations in the London Zoological Garden.

DR. W. V. BINGHAM, president of the Psychological Corporation and director of the Personnel Research Federation, sails with Mrs. Bingham on *The Leviathan*, on October 1, for Paris to participate in the Fourth International Congress of Techno-Psychology. Before returning to New York in November he plans to visit the J. J. Rousseau Institute and the International Labor Office in Geneva, the psycho-technical laboratory of The Philips' Glowlampworks at Eindhoven, Holland, and the National Institute of Industrial Psychology in London.

ASSISTANT PROFESSOR A. E. EMERSON, of the department of zoology of the University of Pittsburgh, who represented the university at the International Congress of Zoologists at Budapest, returns from a year's study in Italy and Sweden.

AT the University of Pittsburgh, leaves of absence for one year have been granted to Professor S. H. Williams, zoology, for study and research in Germany, and to Assistant Professor K. S. Tesh, chemistry, for study and research at the University of Illinois.

A MEMORIAL tablet has recently been unveiled in the naval hospital of St. Anne at Toulon in honor of Dr. Louis Tribondeau, an eminent clinician and bacteriologist, who has given his name to a well-known stain. He died of influenza at Corfu in 1918.

Industrial and Engineering Chemistry reports that a Priestley Medallion has been presented to the Priestley Memorial Museum, Northumberland, Pennsylvania, by Josiah Wedgwood and Sons, Ltd., of Etruria, England. The portrait is in white on the usual Wedgwood blue background and is 12 x 9 inches. It is mounted in a deep walnut frame and the inscription on the back reads as follows: "Presented to the Priestley Museum by Messrs. Josiah Wedgwood and Sons, Ltd., Etruria, England. This replica has been made from the original mould still in the possession of the firm. January, 1927." Josiah Wedgwood, the founder of the firm presenting the medallion, was a friend of Dr. Priestley and many letters passed between them.

IT is proposed to establish an Adami research fellowship in pathology in the University of Liverpool in memory of John G. Adami, F.R.S., who was vice-chancellor of the university during the last years of his life. For this purpose it is proposed to collect the sum of £3,000. Should the sum collected be insufficient, an alternative proposal is the endowment of an Adami Library of Pathology in connection with the medical library.

FRANK SPRINGER, a lawyer of New Mexico, known for his work in invertebrate paleontology, died on September 22, aged seventy-nine years.

CHARLES MCMILLAN, professor emeritus of civil engineering at Princeton University, died on September 19 in his eighty-seventh year. He was the oldest member of the Princeton faculty and of the American Society of Civil Engineers.

DR. CLARENCE HOFFMAN, associate professor of anatomy at Jefferson Medical College, Philadelphia, died suddenly on September 1.

SIR ARTHUR EVERETT SHIPLEY, F.R.S., the zoologist, master of Christ's College and from 1917 to 1919 vice-chancellor of the University of Cambridge, England, died on September 22 at the age of sixty-six years.

THE death is announced at the age of fifty-three years of Professor Rudolf Magnus, who held the chair of pharmacology at Utrecht.

AT the autumn meeting of the American Society of Civil Engineers in Columbus, Ohio, which will be held from October 12 to 15, two days will be devoted to the discussion of the Mississippi Flood Problem, and its various phases will be treated by eminent authorities from both official and private life. Secretary of War Dwight F. Davis and Major-General Edgar Jadwin, chief of engineers, will present the views of the War Department. Other government departments cooperating will include U. S. Geological Survey, through Nathan C. Grover, chief hydraulic engineer; the Mississippi River Commission, through Colonel C. W. Kutz, and the Interior Department through Elwood Mead, commissioner of reclamation. Many other students of flood problems will contribute to the discussion, such authorities as Arthur E. Morgan, of Dayton, Ohio; John F. Coleman, of New Orleans; Colonel William Kelley, of Buffalo, and C. E. Grunsky, of San Francisco.

THE sixth International Congress of the History of Medicine was held at Leyden in July, under the presidency of Dr. J. G. de Lint, lecturer on the history of medicine in the University of Leyden. According to a report in *Nature* there were over eighty papers on the program. Dr. C. A. Crommelin gave an address illustrated by portraits of Huyghens, the Musschenbroeks and other contemporary Dutch scientific workers. Addresses illustrated by kinemato-

graph films were given by Drs. A. Scherbeck and W. H. van Seters on the work of Leeuwenhoek and Swammerdam. Lectures were also given on the history of the treatment of nervous and mental diseases, by Dr. C. O. Ariëns Kappers; the doctor in caricature, by Mr. C. Veeth; and the bier of the surgeons and druggists preserved in the church at Wokkum, by Dr. J. B. F. van Gils. An exhibition was arranged in the Municipal Museum at Amsterdam consisting of pictures by Rembrandt, Jan Steen, Teniers and other works from various Dutch galleries, sculpture, books and *incunabula* illustrating the history of medicine. An exhibition of instruments made by famous Dutch physicists in the seventeenth, eighteenth and commencement of the nineteenth centuries was held at the physical laboratory of the University of Leyden. The next congress will be held at Rome in 1930, but the International Society of the History of Medicine will form a section in the Congress of the History of Science to be held next year at Oslo.

THE International Congress of Hygiene will be held in Paris from October 25 to 28, under the chairmanship of Professor Léon Bernard, director of the Institut d'Hygiène of the Faculté de Médecine of Paris. The following topics have been chosen for discussion: (1) The relations of social insurance systems to the public health; speakers, Kuhn, Copenhagen; Holtzmann, Strasbourg, and Briau, Paris; (2) factors influencing the recrudescence of smallpox throughout the world, and the means of combating them; speakers, Professors Ricardo Jorge, Lisbon; Jitta, The Hague, and Camus, Paris; (3) the hygiene of instruction camps, speaker, Médecin-Inspecteur Sacquepée, professor at École d'Application du Val-de-Grâce. Addresses will also be delivered by Professor Madsen, president of the committee on hygiene of the League of Nations, on "The International Organization of Hygiene"; Professor Nuttall, of the University of Cambridge, on "The Relations of Parasitology to Hygiene," and Professor Ottolenghi, professor of hygiene, University of Bologna, on "The Question of Vitamins from the Hygienic Point of View."

A MR. C. SPIERER, of Geneva, Switzerland, has been an experimenter and inventor of ultra-microscopes for colloidal investigation and has devised an ultramicroscope involving a new principle of double illumination. Dr. Ellice McDonald, of the University of Pennsylvania, has been in correspondence with Mr. Spierer for several years in regard to the application of his instruments to colloidal research in cancer and has applied Mr. Spierer's methods. This has finally resulted in a gift by Mr. Spierer for use in research of all his microscopic equipment to Dr. McDonald and Professor Seifritz, of the University of Pennsylvania.

PROTECTING the sea-front along the Scripps Institution of Oceanography, University of California, assembly bill 368 has been passed by both houses of the legislature and signed by Governor Young. This bill creates a biological reserve along the shore-line of the institution, and prevents all fishing and collection of marine life to a mean low tide depth of six feet, which includes outlying rocky ledges. This action was taken because of the threatened extinction of many kinds of marine animals in these waters.

UNIVERSITY AND EDUCATIONAL NOTES

BY the will of the late Eldridge R. Johnson, formerly president of the Victor Talking Machine Company, the University of Pennsylvania receives $800,000 for the establishment of the "Eldridge R. Johnson Foundation for Research in Medical Physics." It is stipulated that a sum not exceeding $200,000 may be expended for a building and equipment for the foundation. Any income from the balance will go to further the "study and development of physical methods in the investigation of disease and in its cure; the study of the important physical agencies or properties, such as heat, light, electricity, sound, etc., in their varied relations to the life of man, and to carry out investigations for the improvement of the instrumental applications of such agencies to medical purposes."

Nature states that the Albert Agricultural College, Glasnevin, Dublin, which has been engaged in agricultural teaching and research since 1851, has recently been reorganized so as to accommodate the enlarged Agricultural Faculty of University College, Dublin (National University of Ireland), and will henceforth be under university control. The following appointments have been made: director and professor of agriculture, Professor J. P. Drew; professor of plant pathology, Dr. P. A. Murphy; lecturer in animal nutrition, Mr. E. J. Sheehy; lecturer in agricultural chemistry, Mr. Geo. Stephenson; lecturer in agricultural botany and bacteriology, Mr. M. J. Gorman; lecturer in plant breeding, Mr. M. Caffrey; lecturer in horticulture, Mr. G. O. Sherrard.

DR. HENRY HARTMAN, professor of pathology, University of Texas School of Medicine, Galveston, has been appointed dean of the medical school, succeeding Dr. William Keiller. Dr. Hartman for many years has been a teacher in the college and since March, 1926, has been the acting dean.

DR. PAUL D. FOOTE, late of the Bureau of Standards at Washington, has been appointed to a senior fellowship in the Mellon Institute and a lectureship in the department of physics of the University of Pitts-

burgh. Dr. Robert T. Hance, of the Rockefeller Institute of Medical Research, has been appointed professor and acting head of the department of zoology. Professor F. L. Bishop retires as dean of the Schools of Engineering and Mines to devote full time to the department of physics. Dr. W. E. Baldwin, instructor in chemistry, goes to the Johnstown Junior College of the university as assistant professor and director of the department of chemistry.

DR. G. L. FOSTER, assistant professor of biochemistry in the University of California Medical School, at Berkeley, has resigned to become associate professor of biochemistry in the Medical School of Northwestern University.

R. B. GREEN, who has held the position of lecturer in anatomy at the College of Medicine, Newcastle-on-Tyne, for the past five years, has been elected professor of anatomy in the University of Durham, in succession to Professor R. Howden.

DR. WILHELM TRENDELENBURG, who was recently called from the professorship of physiology at Tübingen to the University of Berlin, has been succeeded at Tübingen by Dr. Armin Tschermak von Seysenegg, of the German University at Prague.

DISCUSSION AND CORRESPONDENCE

ARSINE FROM FUSED GLASS

RECENTLY while drawing a large tube of borosilicate glass to capillary size a very pronounced garlic-like odor was observed. After a number of failures to duplicate the conditions it was found that the odor could be noticed only during the process of drawing the glass and thus while continuously forming a fresh surface.

The experimental procedure was as follows. The center portion of a short length of tubing was fused to a thick mass in an oxygen-natural gas flame. If the fused mass was held close to the nose no odor could be detected until the glass was stretched when at once the odor of garlic was noticed.

The experiment was repeated with a second lead-free borosilicate glass. This glass had a somewhat higher melting point and the odor could not be detected in this case unless the fused glass, after removing from the flame, was allowed to cool until it could be stretched only with difficulty. Several samples of so-called soft glasses gave negative results.

The odor was so striking that it was compared with that of arsine from an arsine generator. Several observers agreed that the odors from the fused glasses and of the arsine were identical. Since the two glasses giving positive results were found on analysis to contain in one case 0.5 per cent. and in the other 0.8 per cent. of arsenic oxide, one might safely conclude that the odor from the glass is due to arsine were it not for the fact that arsenic vapor is itself supposed to have a garlic-like odor.

When arsine is heated in the air it is largely oxidized to As_2O_3, the equation for the main reaction being as follows:

$$4As + 3O_2 = 2As_2O_3. \quad (1)$$

Water vapor which is always present in the air may aid in the oxidation according to equation (2),

$$2As + 3H_2O = As_2O_3 + 3H_2. \quad (2)$$

Arsenic oxide, As_2O_3, has no odor either in the solid or gaseous phase and since hydrogen is odorless it would appear, unless there are other products of the oxidation, that gaseous arsenic is responsible for the garlic odor which accompanies the heating of arsenic in the air.

There is another possible product not of the oxidation, but of the reduction of arsenic, namely, arsine. The hydrogen formed according to equation (2) might reduce some of the arsenic to arsine as follows:

$$2As + 3H_2 = 2AsH_3, \quad (3)$$

or better still, the effect of water vapor on arsenic vapor might be considered as a single reaction:

$$4As + 3H_2O = As_2O_3 + 2AsH_3. \quad (4)$$

Here part of the arsenic acts as an oxidizing agent and is reduced to arsine while the remainder is oxidized to As_2O_3.

The analogous reaction between water vapor and phosphorus has been shown to take place[1] very readily at high pressures and temperatures thus:

$$4P_2 + 12H_2O = 3H_3PO_4 + 5PH_3. \quad (5)$$

If reaction (4) takes place only to a very slight extent when arsenic is heated in air we can readily explain the similarity of its odor to that of arsine. In dry air reaction (4) may even be delayed until contact of the arsenic vapor with the moist mucous membrane of the nostrils.

It is therefore suggested, first, that the odor of arsenic vapor is due to the presence of arsine; second, that under the proper conditions arsine is formed in the fusion of glass containing arsenic compounds.

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[1] Ipatier and Nikolajev, Ber. 59 (B), 595 (1926).

INDICATIONS OF THE TRANSMISSION OF AN ACQUIRED CHARACTER IN FLAX

IN the great field of plant and animal growth, change of form and type through development and adaptation, evolution is always in evidence. No two individuals are ever quite identical. Darwin seems to have conclusively proved that the thought "once a species, always a species" is untenable. Since his epoch-making labors, most biologists are quite agreed that species, varieties and strains continually show changes of type and character; but how do these changes come about?

In all types where open crossing is possible, it is easy to understand that an endless number of combinations of form and character may arise through various unions of units of form, quality or character. Thus, through Mendelian studies and methods it is easy for the formalists, given to mathematical methods, to account for any number of noticeable forms and qualities. Hence, if followed to the ultimate conclusion along such line of reason, species, varieties and individuals again become fixed recurring entities which can not be changed or modified in actual nature except it be through the recombination of certain fixed hereditary particles.

Of late, plant and animal breeders and leading geneticists have held that these recombining parts or particles are either represented by the chromosomes, or are contained within them as the genes. The genes, as such, approach philosophical or hypothetical units of heredity. They are assumed to be carriers or bearers of hereditary characters. The whole scheme of thought is entrancingly interesting, and appears to work out so well for properly contrasted units of form or character that it can be looked upon as an almost certain basis for predicting the general type of progeny which may follow upon the development of any given set of cross-mating.

It is but fair to say that this line of investigations and thought carries very great hope for plant and animal improvement, including man himself. It is, perhaps, the greatest working hypothesis yet given to the biologist.

However, the old thought that acquired characters may be transmitted and do in fact account for evolutionary progress and development, need not be dismissed as wholly untenable. The Mendelian theories and formulas do not explain the origin of the genes, nor is it proved that these may not be subject to change. It is with this thought in mind that I call attention to the wonderful work done by many workers in immunization against disease in animals, and to the yet more pronounced work of procuring disease resistant and climate resistant plants. In these lines of work there rests evidence of progressive evolution that can not be accounted for through the hypothesis of permanent, never-changing chromosomes or by the genes which may be lodged therein. If these never change in substance or character, then there could never have been a beginning, hence no change or evolutionary development.

In my own work of developing numerous strains or varieties of wilt-resistant flax, these points become very plain. From numerous varieties of non-resistant flaxes, I have been able through constantly submitting the same to ever-increasing degrees of disease attack, to bring about a high degree of immunity to Fusarial attack, without any associated evidence of cross-fertilization. Equally pronounced results are indicated as against flax rust.

When these strains which have accumulated a certain degree of resistance to a fungus attack are crossed artificially upon non-resistant strains, they transmit a definite degree of immunity to the resulting progeny. Thus we are now able to develop and throw the resistance to Fusarial wilts through crossing into any type or variety of flax desired through artificial crossings of the resistant strains upon the non-resistant strains or varieties. Mendelianists have suggested that such resistance as we have thus procured is but accidentally selected or picked up because of "fortuitous field crosses." However, flax is a closely fertilized plant and in all our work I have not seen sufficient evidence of open crossing to account for the rapid accumulation of wilt resistance.

During many years of continuous planting side by side, it is possible to grow numerous varieties and selection strains without there appearing in the product any evidences of breaking up of the noticeable characters of flowers or of other morphological parts because of fortuitous crossing. We have grown hundreds of individuals from individual plants and from individual seeds for the distinct purpose of observing this feature. It probably does not occur in sufficient extent to in any way affect the results in accumulating wilt resistance which we have here obtained.

Our results indicate no other conclusion than that wilt resistance may be accumulated rather rapidly by a non-resistant strain or variety and that, when it is thus accumulated, it is transmitted from generation to generation through seed; and, further, that when once obtained to a certain degree, it can be fixed through artificial crossing.

This appears to be the final proof of the transmission of an accumulative quality. Besides, if such a quality of resistance can not be so accumulated in nature, how can we account for such features as the

gradual but rather rapid acclimation in corn? If such qualities do not arise in nature by or through gradual accumulation in association with constant crossing, how then did the first gene or unit of character arise? How did the first plant become resistant for any character?

I write simply to suggest that it is well for plant physiologists, ecologists and plant breeders to hold the open mind over against the thought of "Once a gene, always a gene."

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MECHANISM OF BUFFER ACTION IN SOILS

While working on "The Rôle of Pectin in Jelly Formation" it was found that the buffer action of the pectin solutions was due entirely to the impurities in the solution and not to the colloidal properties of the pectin.

It previously had been assumed, while outlining the method for the attack of the problem involving a fundamental study of the mechanism of buffer action in soils, that the buffer action exhibited by certain types of soils was, for the most part, due to the colloidal content of the soils. This assumption was based on the fact that soils high in colloidal matter showed considerable buffer action while soils low in colloidal matter showed scarcely any buffer action.

In view of the results obtained with pectin solutions the plan of attacking the soils problem was changed so that now an attempt is being made to attribute the buffer action exhibited by the several soils to the impurities held by the colloidal fraction, perhaps by electrostatic attraction, double decomposition or neutralization of alkali with an acid or *vice versa*.

Some preliminary work has been done, using a Portsmouth loam, high in organic material. The colloidal fraction was separated and electro-dialyzed thus removing the greater part of the iron, aluminum, manganese, calcium, magnesium, sodium, potassium and other elements, as well as sulphates, phosphates and other acid radicles. As the electro-dialysis progressed samples were frequently withdrawn and their buffer action determined. It was found, during this preliminary work with this particular type of soil, that as the impurities were progressively removed from the colloidal organic fraction of the soil, the buffer action steadily decreased until, the impurities becoming negligible, the sample exhibited scarcely any buffer action.

As a result of this preliminary investigation the work is being continued, using various soil types with the hope of obtaining data sufficient to substantiate the claim that buffer action peculiar to soil types laden with colloidal material is not due directly to the colloidal properties of the soil but rather to the salts, metallic or acid radicles that are held by the colloidal fraction.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

A METHOD FOR OBTAINING INFECTIVE NEMATODE LARVAE FROM CULTURES[1]

Creeping eruption, a human skin disease frequently encountered during the summer in some of the Southern areas of the United States, was shown by Kirby-Smith, Dove, and White[2] to be caused by third-stage nematode larvae. Later White and Dove[3] demonstrated that dogs and cats are concerned in the causation of the disease.

Much culturing has been necessary in the search for the adult worm of the causal parasite and in other studies in which infective larvae have been used. The useful Baermann apparatus was first employed to recover the infective larvae from the cultures. Later a still simpler method was devised which reduced very materially the time required. This latter method has been employed for a year and a half and has proved to be entirely adequate for the problem. An outline of it is given in the present article.

The method makes use of the fact, often observed, that the larvae of a number of parasitic nematodes as they approach the third larval stage and the close of the free-living period tend to migrate from the medium in which they are growing. The apparatus traps many of the migrating worms.

Convenient and sufficient equipment consists of crystallizing dishes 125 to 150 mm. in diameter, watch-glasses slightly larger than these dimensions respectively, Petri dishes 100 to 125 mm., test-tubes 20 by 150 mm., filter papers 9 to 12 cm., a spatula with a 4-inch blade, a test-tube rack, a three-quart boiler with cover, animal charcoal, and sterile water. Brief steaming in the covered vessel suffices for all sterilization that is needed.

The charcoal and the feces are properly mixed conveniently in one of the larger watch-glasses and transferred to the half of a Petri dish, with a moistened

[1] Read before the Washington Helminthological Society, April 16, 1927.

[2] Kirby-Smith, J. L., Dove, W. E., and White, G. F., "Creeping Eruption," *Arch. Dermat. and Syph.*, xiii, Feb., 1926, 137–173.

[3] White, G. F., and Dove, W. E., "Dogs and Cats Concerned in the Causation of Creeping Eruption." Official Record, U. S. Dept. Agr., Oct. 27, 1926, *V*.

filter paper covering the bottom. Sterile water is poured into a crystallizing dish sufficient to cover the bottom and into it is placed the half Petri dish containing the culture. A watch-glass is used as a cover. The apparatus (fig. 1) after labeling is placed for

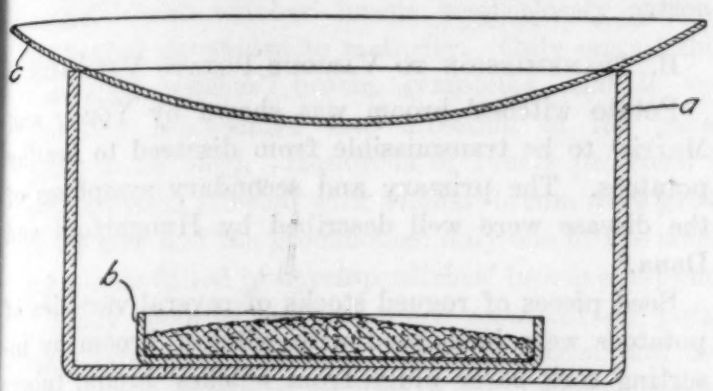

FIG. 1. Apparatus used for culturing nematode larvae. *a*, Crystallizing dish; *b*, Petri dish with charcoal-feces mixture; *c*, watch-glass cover. Water surrounds the Petri dish equal to about one half its depth.

incubation of the culture preferably where a high humidity can be maintained.

Many of the larvae on approaching the third larval stage migrate from the culture and are trapped in the water surrounding the Petri dish. In collecting them the watch-glass cover is removed and the half Petri dish with the charcoal culture is lifted out, preferably with forceps, and placed into it. The water containing the larvae is poured from the crystallizing dish into a test-tube which is then stood perpendicularly in the rack. The worms soon gravitate to the bottom of the tube, after which the water above may be pipetted off, leaving the larvae concentrated. The apparatus with the charcoal mixture may then be reassembled and sterilized by steaming.

A number of modifications of the apparatus and the method may be made to meet the worker's special needs. When there is but a small amount of culture it is well to use the half Petri dish with the bottom up. A Syracuse watch-glass or the top of a Coplin jar serves well in place of the Petri dish. Room temperature, especially in summer, may be substituted for the more constant one of an incubator.

A modified form of the apparatus has been used to reduce somewhat the amount of fungous growth in the culture when this seemed desirable. An aluminum pan of the diameter of the crystallizing dish, with the inclined side perforated, is placed beneath the watch-glass cover and supported by the edge of the dish. Into the pan is poured a few cubic centimeters of an aqueous solution of formalin. A 15 per cent. solution has been employed successfully, but the optimum strength should be determined by each worker to meet his own needs.

As many as 8 species of nematodes, representing 4 genera, have been cultured and isolated successfully by this method, an ample number of larvae of each species being obtained. In no case, however, have all the larvae in the culture been recovered. Additional ones may be had by transferring the charcoal culture to the Baermann apparatus.

While using the method one soon learns of its limitations and its advantages. The larvae are recovered from the cultures in relatively clean water. Only infective forms are obtained. A considerable leeway is permitted as to the time larvae may be collected from the apparatus. The first larvae trapped may be poured off, more water added, and the apparatus reassembled for later migrations. In field work in connection with studies on creeping eruption Dove and the writer have found this method for obtaining infective larvae very convenient and efficient.

In making studies on the migration of nematode larvae, Looss[4] trapped them in water but apparently did not employ the observation in devising a routine method for obtaining larvae from cultures.

Among those who have taken advantage of the migrating tendency of larvae in devising methods suitable for their studies is Darling,[5] who used Syracuse watch-glasses in the center of which he placed 3 to 5 cc. of stool and added sterile water until the feces were surrounded with fluid. The worms for study were taken from this margin of water. Fülleborn[6] also made use of this habit, employing agar plates. The charcoal-feces mixture was placed on this medium in the center of the Petri dish. The infective larvae migrating from the culture over the agar cause their trails to be inoculated with bacteria. By the growth of these the courses taken by the worms are readily observed. Sandground,[7] commenting on different culture methods, points out that the one employing the Baermann apparatus has served the needs of certain of his problems better than others which he has used.

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[4] Looss, A., "The Anatomy and Life-History of *Agchylostoma duodenale* Dub." *Recds. of Egypt. Govt. Sch. of Med.*, Cairo, 1911, *IV*.

[5] Darling, S. T., "Strongyloides Infectious in Man and Animals in the Isthmian Canal Zone," *Jr. Exp. Med.*, July, 1911, xiv, pp. 1–24.

[6] Fülleborn, F., "Nachweis von Ankylostomum durch Plattenkot-cultur." Vorl. Mitteilg. *Arch. f. Schiffs und Tropenhyg.*, 1921, pp. 121–123.

[7] Sandground, J. H., "Biological Studies on the Life-Cycle in the Genus *Strongyloides* Grassi, 1879," *Amer. Jr. of Hyg.*, May, 1926, vi, 337–388.

SPECIAL ARTICLES

TRANSMISSION OF POTATO WITCHES' BROOM TO TOMATOES AND POTATOES

(Preliminary Report)

A. Transmission from Potatoes to Tomatoes

In the greenhouse of the Montana Agricultural Experiment Station at Bozeman, Montana, stems of 18 Earliana tomato plants 20 to 75 cm. tall were inarch-grafted on to the stems of 18 potato plants which showed severe symptoms of witches' broom. The potatoes were grown from seed pieces inoculated with tuber plugs from potato tubers infected with witches' broom. These potato plants were selected because they developed large stems before the witches' broom appeared. Seven of these 18 grafted tomato plants showed definite symptoms of a peculiar disease within 53 days after grafting. Two of the other grafted tomato plants exhibited the disease symptoms within 73 days after grafting. The top of one plant became chlorotic within 13 days, and another within 30 days after grafting. Of the nine grafts which transmitted the disease, five were known to be true grafts, and graft unions probably occurred also in the others. The witches' broom potato plants which transmitted the disease to the tomatoes were of the following varieties: Bliss Triumph, Russet Burbank, Perfect Peachblow, Blue Victor and Rural New Yorker.

The other nine grafted tomato plants of the above series, and 15 ungrafted tomato plants of the same age and variety showed no symptoms of the disease. Two of the checks were in the same pots with tomatoes which developed the disease.

The symptoms of the disease transmitted from witches' broom potato plants to tomato plants were: The new leaflets had very prominent, yellow-chlorotic margins; they were extremely dwarfed and often rugose. In a small percentage of the leaflets, the lower sides of the veins were purple. Many of the new leaflets had very narrow leaf blades. None of the leaflets was upward rolled. In many cases the rhachises of the leaves were prominently downward curled. The new tops of the affected plants were very chlorotic. They bloomed profusely and produced many small tomatoes; the buds and flowers developed normally.

Western yellow tomato blight and linear and rugose tomato mosaics have some of the symptoms described above. Since the disease considered here does not have enough of the diagnostic symptoms of any of these three tomato viroses for classification in one of them, and because the symptoms are very similar to the first symptoms of witches' broom in the potatoes from which the disease was transmitted, this disease is tentatively called tomato witches' broom. This is probably the first report of the transmission of the virus of potato witches' broom to a different host.

B. Transmission to Various Potato Varieties

Potato witches' broom was shown by Young and Morris[1] to be transmissible from diseased to healthy potatoes. The primary and secondary symptoms of the disease were well described by Hungerford and Dana.[2]

Seed pieces of rogued stocks of several varieties of potatoes were inoculated with witches' broom by inserting cork borer plugs from witches' broom tubers into holes made in the seed pieces. Thirty-four of the resulting plants developed the first symptoms of witches' broom within 35 to 114 days after inoculation. These tuber plugs formed graft unions with the seed pieces in many cases.

The following data include the cases of transmission previously reported and summarize the data secured: Of the 138 seed pieces plugged with witches' broom scions, 45 produced plants with typical symptoms of witches' broom. The progeny of two other plants showed severe symptoms of witches' broom although the parents exhibited no symptoms of disease. From tuber scions of Bliss Triumph and Jersey Peachblow potatoes, witches' broom was transmitted to Bliss Triumph, Russet Burbank, Perfect Peachblow, Idaho Rural, Green Mountain, Irish Cobbler, Blue Victor, Six Weeks, Mills' Prize, Colorado Pearl and Rural New Yorker potato plants.

Similar tuber plug inoculations failed to transmit the disease to Norwegian Yam, Early Michigan, Early Rose, Producer and Up-to-date potato plants. Russet Burbank and Rural New Yorker plants affected with witches' broom did not exhibit marginal chlorosis of the leaflets. The other nine varieties affected with this disease showed prominent marginal chlorosis, at least in the early stages of the disease.

Forty-five normal seed pieces of Bliss Triumph potatoes, plugged with scions from healthy tubers of this variety, were planted in the greenhouse where they grew for 84 days. None of them developed any symptoms of viroses (virus diseases). Besides these, four Bliss Triumph seed pieces were plugged with scions from Irish Cobbler and Netted Gem tubers,

[1] Young, P. A., and H. E. Morris. "Potato Witches' Broom is a Transmissible Disease," U. S. D. A. Plant Disease Reporter 10 (3): 26–28, 1926.

[2] Hungerford, C. W., and B. F. Dana. "Witches' Broom of Potatoes in the Northwest," Phytopath. 14: 372–383, 1924.

and three Netted Gem and two Irish Cobbler seed pieces were plugged with scions from healthy Bliss Triumph tubers. None of these seed pieces plugged with scions from healthy tubers developed plants with disease symptoms. About 4,000 potato plants uninoculated with witches' broom were closely observed while they developed to maturity. Only one of them developed witches' broom symptoms, and it very probably represented late infection of the parent plant in the field. Hundreds of tubers produced by potato plants affected with witches' broom were grown in the field and the greenhouse; only one of the resulting plants failed to develop witches' broom symptoms.

Mealy bugs (Coccidae) were colonized on potato vines severely affected with witches' broom, and then transferred to four healthy Bliss Triumph potato plants and two healthy Earliana tomato plants; no evidence of disease transmission was seen. Aphids taken from potato vines with severe witches' broom were allowed to feed on the sprouts of two Irish Cobbler potatoes. Neither the resulting plants nor their progeny produced vines with witches' broom symptoms. Seven other attempts to transmit witches' broom by means of aphids all failed. In the field in 1925 and 1926, normal Bliss Triumph potato plants grew beside potato plants severely affected with witches' broom. Since aphids were abundant on both the normal and the diseased potato plants late in the season, tubers from eight of the normal plants were planted in the greenhouse at different times. All the plants grown from these tubers remained healthy, showing that aphids had not carried the disease to their parents from the adjacent vines which had witches' broom.

By leaf mutilations 62 Bliss Triumph, Netted Gem and Irish Cobbler potato plants 12 to 30 cm. tall were inoculated with witches' broom. The inoculations were repeated on many of the plants two or three times, at intervals of a few days. These experiments were performed in the greenhouse during two winters. None of the inoculated plants developed witches' broom symptoms. Eighteen normal potato plants were grown in pots with plants severely affected with witches' broom, but none of the normal plants became diseased. The method of field dissemination of witches' broom is not yet determined.

Most of the witches' broom plants seen in many fields have shown severe symptoms so that the disease was recognizable soon after the sprouts appeared. Tubers infected with witches' broom produce many chlorotic, spindly sprouts. There now appears to be no constant difference between the upright and prostrate forms of witches' broom in the field. In one row of 98 hills of Bliss Triumph potatoes, 56 of the hills were severely affected with witches' broom. The seed pieces weighed about 50 g. apiece and were quarters of tubers. The large size of the seed tubers indicated that they very probably came from parent vines infected late in the season. Plants infected early in the season rarely produce tubers of marketable size.

In the greenhouse the development of a potato plant successfully inoculated with witches' broom by tuber grafting is as follows: The plugged seed piece produces a plant which remains normal in growth and appearance for 31 to 114 days. If the mosaic virus be present in either the stock or the scion, its symptoms appear within the first month or two and precede the witches' broom symptoms. The presence of mild or crinkle mosaic does not interfere with the development of witches' broom. The first symptom of witches' broom consists of an increasingly prominent chlorosis of the new leaflets on one or more stems. In most varieties of potatoes the margins of the new leaflets are chlorotic yellow. Red or purple colors often occur in the new leaflets, particularly under field conditions. The top of the plant then elongates with abnormal rapidity, and produces a stem which is cylindrical with enlarged nodes; it is chlorotic and often purpled.

Many chlorotic, spindly axillary branches develop all along the stem and bear typical witches' broom leaves. The abnormally numerous axillary branches, sometimes borne by plants with severe spindle tuber, are thick, green, and not spindly, so they are unlike those borne on witches' broom plants. Filamentous aerial stems are valuable in diagnosis when they occur; they are often numerous. Small numbers of these peculiar stems occur in the field.

Spindly sprouts appear as aerial or subterranean stem branches at the base of the plant and grow very slowly, representing witches' broom in severe form. The tubers already formed often sprout and add to the number of spindly basal sprouts. Vigorous plants may have 200 or more very slender stems, and a large number of very small tubers. In most cases the top of the plant continues to grow rather rapidly for the next few months and may reach a height of 1 m. Such plants frequently bloom earlier and more profusely than normal plants. The old leaflets produced while the plant was normal slowly die and are replaced by the dwarfed, chlorotic leaves produced by the spindly tops and branches. The dwarfed, new branches often bear only minute, simple leaves. Filamentous aerial stems and aerial tubers commonly occur on all parts of the stems. Flowers were borne on the aerial tubers of a few plants, but this is an uncommon symptom.

Finally, the tall main stems die completing the transformation of the normal potato plant into a